Presentation description of LAPC 2013 paper / poster entitled

Energy efficient gully pot monitoring system using Radio Frequency Identification (RFID)

A. Atojoko, N. A. Jan, F. Elmgri, R. A. Abd-Alhameed, C. H. See, J. M. Noras

This paper presents two different RFID passive tags designed, simulated, modeled and deployed for gully pot monitoring. The measured and simulated results are presented. A comparative analysis was given on both design realization, in terms of their performance in proximity to water surfaces.

A brief summary to the research work and scope is presented in **slide 2**. **Slides 3** outlined the project work in general. **Slides 4 and 5** are explicitly spells out the main targets and project objective of the proposed design.

Slide 6 presents a pictorial view and design parameters of the two passive tag antenna realizations. The main difference between them is the existence of ground plane in the second design to avoid the maximum coupling with the wall of the gully pot. Both designs deliver improved results in terms of the radiation performances and the required RFID chip impedance matching.

Slide 7: Discusses the simulation results scenario, a full parametric study was performed using HFSS from which a candidate structures have been fabricated .The reflection coefficient over bandwidth centred at 867MHz and gain values are presented with satisfactory results for the deployed application.

Slide 8: A diagrammatical illustration of the experimental set up is presented here showing the distances and angles of alteration of the reader antenna from the tag antenna in order to obtain readings on the read range of the designed tag.

Slide9: shows the Gully pot measurements as modelled in HFSS to reflect a real life scenario. The linear relationship between the level of water in the Gully pot and the communication signals received on the reader software database is also graphically presented

Slide10: Identifies the challenges faced by domestic and industrial sectors as a result of flooding(water/ liquefied gas) Concludes and comments on the successful practical implementation of a cost effective, energy efficient and robust gully pot monitoring system which adequately addresses these challenges.

Slide11: Gives an expository insight into ideas generated as a reflection of future work to be done to extend the current research work.

Slide 12-15: References

ENERGY EFFICIENT GULLY POT MONITORING SYSTEM USING RADIO FREQUENCY IDENTIFICATION (RFID)

Achimugu Alpha Atojoko,
N. A. Jan, F. Elmgri, R. A. Abd-Alhameed, C. H. See, J. M. Noras

University of Bradford, UK

SUMMARY

Sewer and gully flooding have become major causes of pollution particularly in the residential areas majorly caused by blockages in the water system and drainages. An effective way of avoiding this problem will be by deploying some mechanism to monitor gully pot water level at each point in time and escalating unusual liquid levels to the relevant authorities for prompt action to avoid a flooding occurrence. This paper presents a low cost power efficient Gully pot liquid level monitoring technique. Passive RFID tags are deployed and signal variation from the Alien Reader Software are used to effectively estimate the level of liquid in the gully pot. The experimental set up is presented and an expository presentation is made of the passive tag design, modelled and simulated and adopted for same application

OUTLINE

- Sewer and gully flooding have become major causes of pollution particularly in the residential areas majorly caused by blockages in the water system and drainages. Underground /surface leakage of oil and gas pipelines have also caused a lot of harm to the coral reef.
- An effective way of avoiding this problem will be by deploying some mechanism to monitor gully pot water level at each point in time and escalating unusual liquid levels to the relevant authorities for prompt action to avoid a flooding/spillage occurrence as the case may be for oil & gas products.
- This paper presents a low cost, power efficient gully pot liquid level monitoring technique. An RFID system is made up of the RFID tag, reader, RFID software and a database. The reader scans the tags simultaneously and transmits the information to a database where it is stored for referencing. Passive RFID tags are deployed and signal variations obtained from each of these level sensors form a basis for effective estimation of liquid level in a surface/underground vessel.
- The experimental set up is presented and an expository presentation is made of the passive tag design, modelled and simulated and adopted for underground liquid level indication both for residential and commercial use.

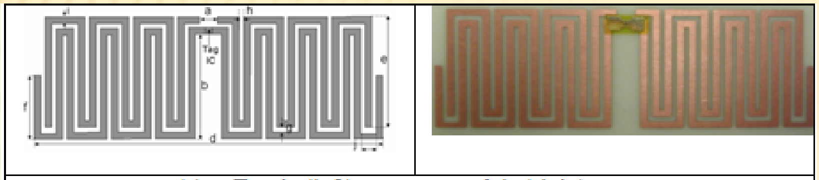
MAIN TARGETS

- To design, model and simulate using HFSS a passive RFID tag deployed for power efficient gully pot liquid level monitoring.
- To demonstrate that liquid level data can be effectively collected using energy efficient and less expensive RFID network .

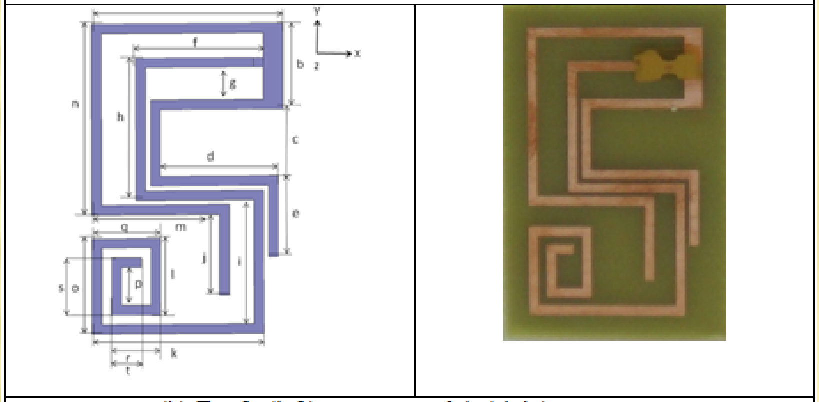
MAIN OBJECTIVES

- To design and model a sample passive transceiver using the HFSS platform for simulation,
- To improve the tag radiation characteristics by altering various geometry parameters,
- To benchmark results obtained with agreed performance indicators: Gain, Directivity, Read/Write range, orientation sensitivity,
- Subjecting the designed tag to practical measurements and comparing these results to the theoretical results obtained.
- Programming the tags with the ‘Alien RFID reader software’
- Deployment of tags on the different levels indicated and altering the soil and gully characteristics while changes to signal variations are observed with each change.

TAG PROTOTYPE DESIGN



(a) Tag 1; (left) antenna model; (right) prototype.



(b) Tag 2; (left) antenna model; (right) prototype.

Figure 2: RFID tag antennas; (a) tag 1 without ground plane; (b) tag 2 with ground plane.

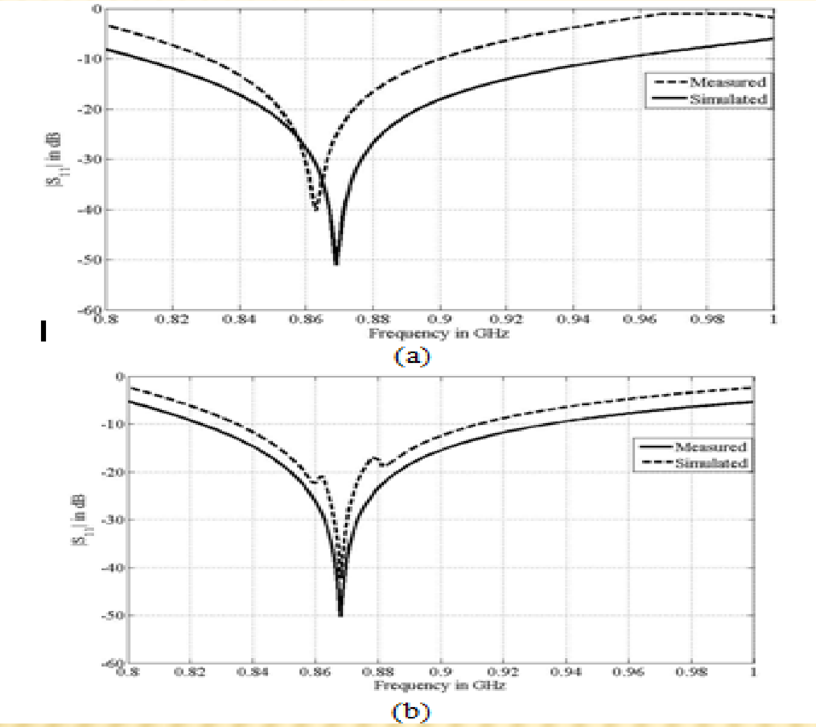
Table 1: Parameters of the proposed RFID tag 1.

a	3.2	**e**	19.8	**h**	0.8
b	19	**f**	11.5	**i**	1.2
c	4.8	**g**	0.9	**j**	2.8
d	63.2				

Table 2: Parameters of the proposed RFID tag 2 with ground plane.

A	19.5	**k**	17.5
B	9	**l**	8
C	0.5	**m**	13
D	12	**n**	20
E	8.5	**o**	10
F	13	**p**	4
G	0.5	**q**	7
H	14.9	**r**	5
I	13	**s**	6
J	8.5	**t**	2

SIMULATION RESULTS



Refection coefficient$|S_{11}|$ in dB; (a) tag 1; (b) tag 2.

- ➢reflection coefficient over bandwidth centred at 867MHz is approximately between -18 to 35 dB for both antennas

- ➢The gain values were quite satisfactory between (-2.1 to -0.5)dBs and (-3.2 to -1.1)dBs respectively for tag 1 and tag 2 antennas.

Both designs deliver improved results in terms of the radiation performances and the required RFID chip impedance matching

EXPERIMENTAL SET UP

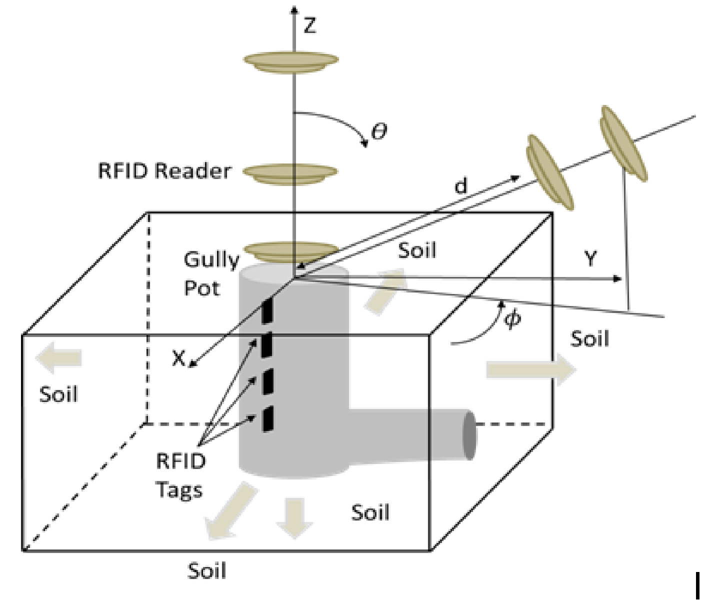
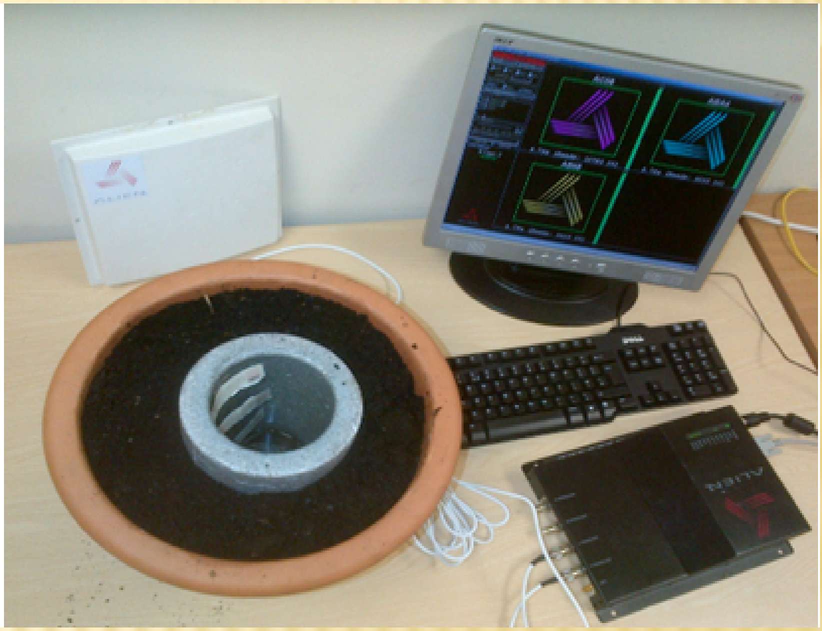
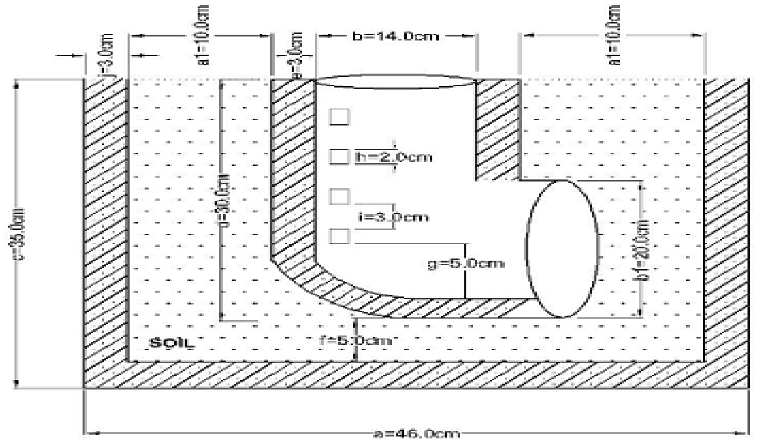

Z
θ
RFID Reader
d
Gully Pot
Soil
Y
ϕ
Soil
X
Soil
RFID Tags
Soil
Soil

Fig. 1: Gully pot set up Illustration

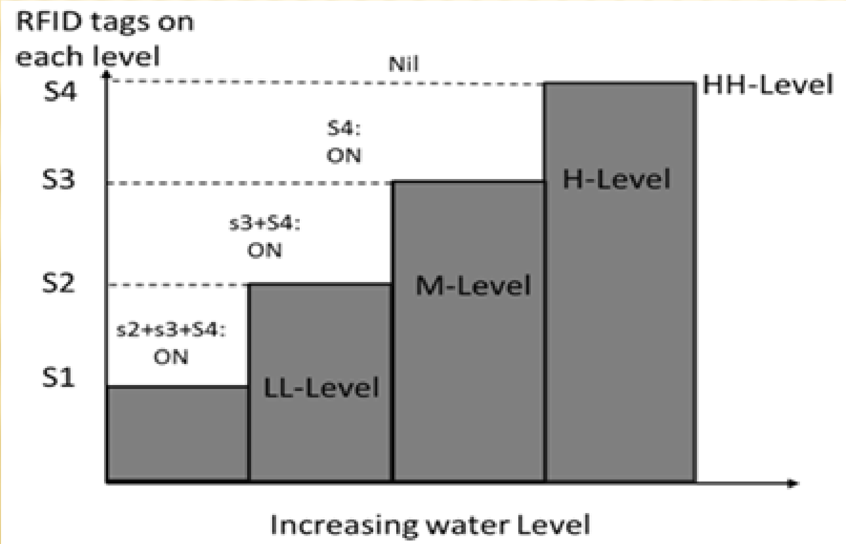


➢The tags were laminated and placed on their respective levels LL-Lower level, M-Mid level ,H-High level and HH-Highest level within the gully.
➢The gully was slowly filled with water to cover each level and the results obtained were displayed accordingly.

GULLY POT MEASUREMENTS FOR HFSS


j=3.0cm
a1=10.0cm
e=3.0cm
b=14.0cm
a1=10.0cm
c=35.0cm
d=30.0cm
h=2.0cm
i=3.0cm
g=5.0cm
b1=20.0cm
SOIL
f=5.0cm
a=46.0cm

a=46.0cm;
a1=10.0cm
b=20.0cm;
b1=20.0cm
c=35.0cm
d=30.0cm
e=3.0cm
f=5.0cm
g=5.0cm
h=2.0cm
i=3.0cm
j=3.0cm


RFID tags on each level
S4
S3
S2
S1
Nil
HH-Level
S4: ON
H-Level
s3+S4: ON
M-Level
s2+s3+S4: ON
LL-Level
Increasing water Level

There is a linear relationship between the level of water in the gully pot and the communication achieved at each level

CONCLUSION

Flooding and oil pipeline spillage associated issues both at the consumer, water companies and oil and gas company respectively perspective has posed a lot of problems.

The design of the power efficient system for surface and underground gully pot monitoring offers an effective solution to this tremendous challenge. This paper presents the practical implementation of a cost effective Gully pot monitoring system using RFID technology. Remote independent and effective monitoring of gully pot water levels in real time is achieved for data collection and transmission for distant operator station monitoring to prevent and effectively reduce sewer flooding and oil spillages. The designed passive tags are low cost and easy to deploy. The results obtained from the practical experimental set up has enabled the researcher develop better understanding on the working elements and the problems associated with the liquid level monitoring system

RECOMMENDATIONS FOR FUTURE WORK

- To design and produce a prototype of an RFID reader antenna with high directivity for improved read/write rates, using the HFSS software.
- Incorporating the reader antenna designed with the tags as a complete system and analyzing the signal coupling between reader antenna and tags using the HFSS software to obtain results for different scenarios of wet and dry soil, altering the nature of soil and gully pot material to capture practical conditions.
- Extending the RFID tag design with a physical input port for sensors to achieve a direct sensor-tag- remote database information transmission.
- Developing a prototype of an energy efficient solar powered RFID reader with Wi-Fi and UMTS communication capabilities.

REFERENCES

- Ryo Imura, Driving ubiquitous Network-How can RFID solutions meet the customer's expectations.10th International Conference on emerging technologies and factory automation Italy 2005.
- Distributed design of RFID network for large-scale RFID deployment 2006 IEEE International conference on industrial informatics
- OFWAT, "Service and Delivery- performance of the Water Companies in England and Wales 2007-08 Report", http://www.ofwat.gov.uk/regulating/reporting/rpt_los_2007-08.pdf
- Hayward P. 2002 Sewerage: fairytale spending, water and waste treatment 35(8), 30-31.

REFERENCES CONTD……

- Siden, J.Xuezhi Zeng ; Unander, Tomas ; Koptyug, A. ; Nilsson, Hans-Erik Sensors, Remote Moisture Sensing utilizing Ordinary RFID Tags 2007 IEEE Digital Object , 2007 , Page(s): 308 - 311
- A. Denote, “The monopole-antenna: a practical snow and soil Wetness sensor”, *IEEE Trans. Geoscience and Remote Sensing,*Vol. 35, Issue 5, pp. 1371 – 1375, Sept. 1997.
- J. D. Griffin, G. D. Durgin, A. Haldi and B. Kippelen, “RF tag Antenna performance on various materials using radio link budgets”, *Antennas and Wireless Propagation Letters,* Vol. 5, pp. 247 – 250, 2006.
- D. M. Dobkin and S. M. Weigand, “Environmental effects onRFID tag antennas”, *IEEE Int. Microwave Symp. 2005*, pp. 135-138.
- J. Sidén, H.-E. Nilsson, “Adaption to Background Material for Printed RFID Antennas”, *In Proc. Antenn-06*, Sweden, 2006.
- F. Menke, R. Knochel, T. Boltze, C. Hauenschild, and W. Leschnik,“Moisture measurement in walls using microwaves”, *IEEE Int.Microwave Symp.* 1995, Vol. 3, pp. 1147 – 1150, 1995.
- ,

REFERENCES CONTD…

- J. Sidén, Xuezhi Zeng, T.Unander, Andrey Koptyug, Hans-Erik NilssonRemote Moisture sensing using ordinary RFID tags IEEE sensors 2007 conference
- T. Hauschild, and F. Menke, “Moisture measurement in masonry walls using a non-invasive reflectometer”, *Electronics Letters,* Vol.34, Issue 25, pp. 2413 – 2414, 1998
- J. D. Griffin, G. D. Durgin, A. Haldi and B. Kippelen, “RF tag antenna performance on various materials using radio link budgets”, *Antennas and Wireless Propagation Letters,* Vol. 5, pp. 247 – 250,2006.
- D. M. Dobkin and S. M. Weigand, “Environmental effects on RFID tag antennas”, *IEEE Int. Microwave Symp. 2005*, pp. 135-138.
- J. Sidén, H.-E. Nilsson, “Adaption to Background Material for Printed RFID Antennas”, *In Proc. Antenn-06*, Sweden, 2006.
- Nawale, S.D. ; Sarawade, N.P. “RFID vapor sensor: Beyond identification Sensing Technology (ICST), 2012 Sixth International Conference on Digital Object Identifier, 2012 , Page(s): 248 - 253

REFERENCES CONTD.....

- C.H. See, K.V. Horoshenkov, R.A. Abd-Alhameed, Y.F. Hu and S.J. Tait, A Low Power Wireless Sensor Network for Gully Pot Monitoring in Urban Catchments, IEEE Sensors Journal, vol.12, no. 5, pp.1545-1553, May 2012
- Nasir, A. ; Boon-Hee Soong "PipeSense: A framework architecture for in-pipewater monitoring system" Communications (MICC), 2009 IEEE 9th Malaysia International Conference , 2009 , Page(s): 703 – 708
- Benelli, G. ; Pozzebon, A. ; Bertoni, D. ; Sarti, G. ; Ciavola, P.; Grottoli, E. "An Analysis of the Performances of Low Frequency Cylinder Glass Tags for the Underwater Tracking of Pebbles on a Natural Beach" RFID Technology (EURASIP RFID), 2012 Fourth International EURASIP Workshop , 2012 , Page(s): 72 - 77
- Nasri, N. ; Kachouri, A. ; Andrieux, L. ; Samet, M. Communications, Computing and Control Applications (CCCA), 2011 International Conference " New approach for wireless underwater identification: Acoustic Frequency IDentification (AFID)" 2011